



A publication of the
National Aeronautics and
Space Administration

Mission Highlights STS-74



IS-1995-11-001.074JSC
November 1995

Atlantis-Mir docking adds new gateway

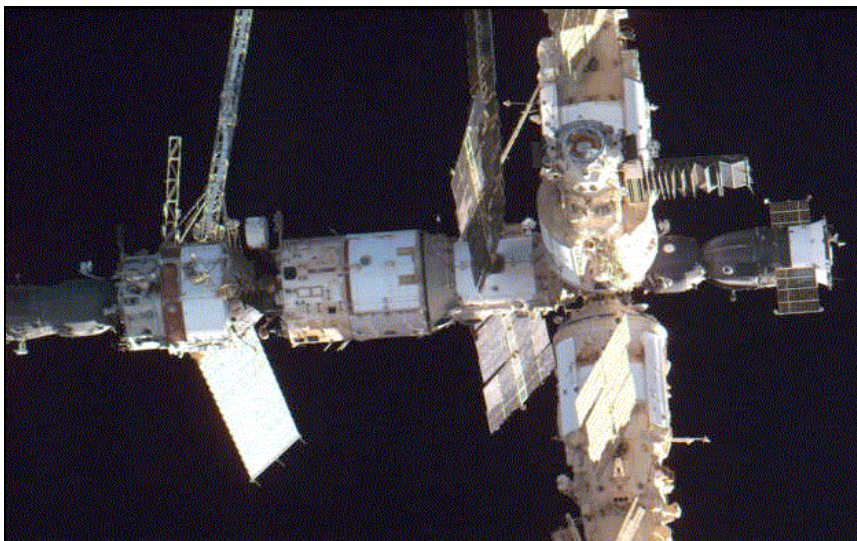
When the Space Shuttle *Atlantis* glided to a landing at Kennedy Space Center on November 20, 1995, it ended an eight-day mission that marked several milestones in the continuing program of joint U.S./Russian cooperation in space.

"I think we left a gateway open for the next five flights," Commander Ken Cameron said. "That's what it's all about—one step at a time toward the (International Space) Station."

The launch of STS-74 at 6:31 a.m. CST began the journey which saw astronauts successfully attach an 8,000-pound, 15.4-foot long docking module to Mir's Kristall module. The docking module will serve as the permanent docking port for all future shuttle/Mir missions.

On Flight Day 3, Mission Specialist Chris Hadfield used *Atlantis*' robot arm to grapple the Russian-built module and hoist it high over the payload bay. He then maneuvered the docking module to a position only four or five inches above the capture ring of the Orbiter Docking System (ODS) in the forward section of the payload bay. At that point, Cameron pulsed *Atlantis*' jets, essentially flying into the ODS capture ring to mate it with the docking ring of *Atlantis*.

Cameron and Pilot Jim Halsell next performed a series of maneuvering burns that resulted in *Atlantis* arriving about 1,000 feet beneath Mir shortly before 11 p.m. on November 14. After receiving approval from the Mission Control Centers in Houston and

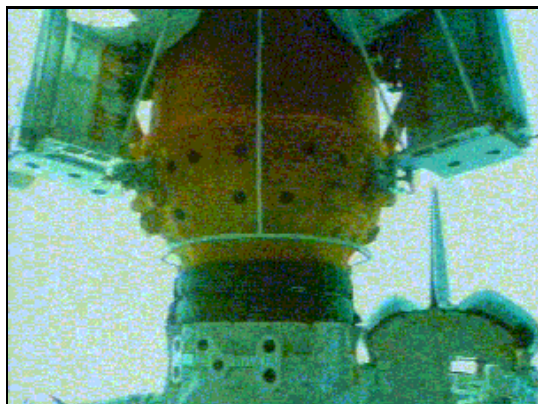


Electronic Still Camera (ESC) image of Mir space station as Space Shuttle *Atlantis* approached for docking.

Space Shuttle *Atlantis*

November 12-20, 1995

Commander:	Ken Cameron
Pilot:	Jim Halsell
Mission Specialist:	Chris Hadfield
	Jerry Ross
	William McArthur



Video camera view of docking module "hard docked" to the shuttle's airlock.

Kaliningrad, Cameron and Halsell began a very slow and precise approach to Mir.

Docking occurred at 12:28 a.m. CST, November 15 as the two spacecraft flew over the Chinese-Mongolian border. At 3:02 a.m. the hatches between Mir and *Atlantis* were opened and the two crews greeted one another in the docking module.

For the next three days, the crews worked side by side transferring equipment, hardware, food, water and other supplies. All told, 2,132 pounds of resupply material was transferred to Mir; while 817 pounds of scientific material and hardware returned to Earth on board *Atlantis*. The shuttle crew also left behind the docking module with its two side-mounted solar canisters.

The astronauts and cosmonauts also jointly accepted congratulatory phone calls from Russian Prime Minister Victor Chernomyrdin, NASA Administrator Daniel S. Goldin, Canadian Minister of Industry John Manley, and Secretary General of the United Nations Boutros-Boutros Ghali.

"We have the same objectives," the U.N. Secretary-General told the crew. "Yours is peace and cooperation in outer space. Our objective is peace and cooperation on Earth."

With the transfer activity complete, the crews bid each other a final farewell before closing the hatches between the two spacecraft in preparation for *Atlantis*' departure from Mir. "It's a bittersweet moment as we leave three friends up here to stay," Ross said as

the hatches closed, separating the STS-74 crew from the Mir 20 crew.

"We've come to the end of the most successful mission I could imagine," Cameron added.

Springs in the capture ring of the docking module gently pushed *Atlantis* away from Mir at 2:16 a.m. CST November 18. Cameron then fired the shuttle's jets to begin a very slow maneuver away from Mir.

Before departing, *Atlantis* flew two revolutions around Mir as the astronauts on board documented the condition of the space station with their on-board cameras.

The crew's final full day on orbit was dedicated to stowage of some of the last Mir transfer items and preparations for *Atlantis*' return to Earth at 11:01 a.m. CST.

Additional payload descriptions

Visual Earth Observations

Experiment: The Earth's surface is changing dramatically everyday, but due to our limited view, these phenomenal events cannot be observed or recorded on a large scale. With space flight and long term habitation in a space station, there is a platform available for continual observations from low-Earth orbit. Sites are selected to document geologic structures using variable Sun angles, seasonal events such as biomass burning, longer-term changes like the rise and fall of lake levels, gradual changes in land-use patterns, dynamic patterns in the ocean surface waters, and globally distributed episodic events like tropical storms, floods, forest fires, volcanic eruptions and dust storms. Researchers for this experiment were from the NASA Johnson Space Center, Lockheed-Martin Corporation and the Russian Academy of Sciences

Fundamental Biology-Greenhouse

Experiment: The experiment was conducted in the Russian/Slovakian-developed plant growth facility called the "Svet." The U.S. has added new lighting and watering systems to enhance plant growth conditions. In

addition, the U.S. has added an instrumentation system to the Svet to gather information on how microgravity affects the gas exchange process in plants. Plant samples were collected at six specific developmental stages and at final harvesting. Researchers for this experiment were from Utah State University and the Russian Institute of Biomedical Problems

Analysis of Volatile Organic Compounds Experiment:

This experiment characterized the volatile organic compounds (VOCs) in air samples collected on Mir during the NASA/Mir program. Samples were collected onto special cartridges using the U.S. Solid Sorbent Air Sampler (SSAS). Also, samples were collected using U.S. Grab Sample Containers. Samples were then transferred from Mir to the shuttle and, when back on Earth, to a laboratory at NASA Ames Research Center for analysis. The results of the analyses revealed detailed information on the types and concentrations of VOCs in the Mir environment. The results also had a number of uses for advanced life support research.

Collecting Mir Source and Reclaimed Waters Experiment:

In this investigation, the water on the Mir space station was analyzed in detail to study the effectiveness of the Mir purification system. Potable water, water used to maintain hygiene, and water that accumulates from humidity condensate was analyzed to confirm that any potentially harmful contaminants were maintained at acceptably safe levels. The information gathered by this research supported the development and evaluation of water purification units, water quality standards, and in-flight water sampling hardware for the ISS. Researchers for this experiment were from the Johnson Space Center and the Russian Institute of Biomedical Problems

Eye/Head Coordination During

Target Acquisition Experiment: The eyes work in conjunction with the vestibular (balance system) in the inner ear, as well as with the other senses, to allow a person to track visual targets while the head and body are moving. Prolonged stays in microgravity change the way the brain responds to eye and head movements when attempting to follow an object

with the eyes. These eye-head coordination tests were designed to study the effects of space flight on eye movement mechanisms controlled by the visuo-motor and vestibular systems, specifically how these systems function separately and how they work together. Researchers for this experiment were from the NASA Johnson Space Center and the Russian Institute of Biomedical Problems.

Humoral Immunity Experiment: The human immune system is comprised of two components, the humoral and cell-mediated immunity. Humoral immunity involves the production and action of antibodies, and cell-mediated immunity involves sensitized lymphocytes. Humoral immunity occurs within minutes or hours of exposure to an antigen.

Cell-mediated immunity, on the other hand, is a delayed reaction occurring days after initial exposure; a good example is a positive reaction seen in the skin 24 to 48 hours after a tuberculosis test injection.

Researchers hypothesize that the humoral component of immunity is depressed during space flight, and that antibody production is significantly reduced. Research of this nature is important to establish and protect the health of the crew during space flight, and also leads to a greater understanding of the human immune system. Researchers for this experiment were from the NASA Johnson Space Center and the Russian Institute of Biomedical Problems.

Inflight Radiation Measurements Experiment: The United States and Russia have different methods of detecting and calculating radiation exposures to their crews and spacecraft. This experiment called for each country's researchers to obtain radiation information in their usual manner. Comparison of the techniques

used by the U.S. and Russia for radiation calculations and dosimetry calibrations enables both countries to validate their radiation detection procedures and identify any differences that exist within their respective protocols. The radiation measurements that occur during this investigation allow scientists to gather additional information about two radiation sources -- galactic cosmic rays and protons trapped by the Earth's magnetic field. Researchers for this experiment were the NASA Johnson Space Center and the Russian Institute of Biomedical Problems

Magnetic Resonance Imaging Experiment: When muscles are not used regularly, they begin to deteriorate and weaken, an effect called atrophy. Bed-rest studies have documented the degree of expected atrophy after several months of muscle disuse. This investigation documented the degree of muscle weakening during long-duration space flight following a stay on the Mir space station. Measurements were made before and after flight using Magnetic Resonance Imaging (MRI). Researchers for this experiment were from the NASA Johnson Space Center and the Russian Institute of Biomedical Problems

Microbial Investigations Experiment: Researchers were interested to learn which microbes inhabit the Mir space station, if the microbes were affected in any way by the lack of gravity, and if concentrations of microbes differ on the Mir compared to on Earth. Researchers for this experiment were from the NASA Johnson Space Center and the Russian Institute of Biomedical Problems

Protein Metabolism Experiment: The human body responds to stressful situations in many ways. One response is an increase in protein metabolism. During shuttle flights, studies have shown that the whole body protein synthesis rate increases dramatically. The experiment was designed to determine how long it takes for protein metabolism to return to the preflight state after a long duration mission. Researchers for the experiment were from the University of Medicine and Dentistry of New Jersey and the Russian Institute of Biomedical Problems

Posture and Locomotion Experiment: Gravity is used as a frame of reference for our sensory-motor response. When gravity is absent, such as during space flight, the sensory-motor system is disrupted. These disturbances are compensated for by the brain, and ultimately the human body adapts to them. After returning to Earth, a readjustment period occurs in which balance and locomotion functions are temporarily disturbed until the brain once again learns to use gravity as a frame of reference. This investigation examined these sensory-motor changes and adjustments. The results assisted researchers in devising countermeasures to reduce the time of adjustment. Researchers for this experiment were from the NASA Johnson Space Center and the Russian Institute of Biomedical Problems



Commanders Yuriy P. Gidzenko and Ken Cameron shake hands across the tunnel created by the docking module.



The combined STS-74 and Mir crews. Front row, left to right Jim Halsell, Bill McArthur and Thomas Reiter. Second row Ken Cameron, Chris Hadfield, Yuriy Gidzenko, Sergei Avdeyev and Jerry Ross.

Renal Stone Risk Analysis

Experiment: It has been suggested that space flight increases the risk of kidney (renal) stone formation, and that the risk is greater during long-duration space flight. This risk was assessed using methods similar to those used on Earth; urine samples were collected over time and analyzed. The concentrations of electrolytes and minerals present in the urine indicate the risk of renal stone formation. Factors contributing to renal stone formation include the urinary concentrations of citrate, oxalate, sulfate, potassium, sodium, calcium, magnesium, phosphate, uric acid, urinary pH, and total urine volume. Researchers for this experiment were from the NASA Johnson Space Center, the Russian Institute of Biomedical Problems, and the Aviation Hospital in Moscow, Russia.

Trace Chemical Contamination

Experiment: Trace chemicals that contaminate the air and water on Mir were removed by several methods. Researchers were interested in characterizing the effectiveness of these methods. The knowledge gained from this investigation provided additional information about the relationship of the air and water on spacecraft and assisted scientists and engineers in developing improved water and air purification units for future space stations. For this experiment, samples were taken at different intervals during the Mir missions, and during STS-74. Researchers used these samples to determine levels of carbon monoxide, methane, hydrogen, and low molecular

weight hydrocarbons. Levels of formaldehyde in the atmosphere were determined by monitors worn by the crewmembers, while other organic compounds are detected by a piece of hardware called the Solid Sorbent Air Sampler (SSAS), which concentrates volatile organic materials from the air. Potable water samples were also taken at several intervals in flight. Researchers for this

experiment were from the NASA Johnson Space Center and the Russian Institute of Biomedical Problems.

Viral Reactivation Experiment: Once a person is infected with a virus, it may be present in the body for the remainder of that person's life and can be reactivated by several factors, including stress. Researchers believe that environmental stress can stimulate reactivation. One example of this viral reactivation is when a person gets a cold sore during a period when they are under stress. This investigation's goal was to determine if the stresses of space flight cause viral reactivation in crewmembers. Researchers for this experiment were from the NASA Johnson Space Center and the Russian Institute of Biomedical Problems.

Mir Audible Noise Measurements

Experiment: Besides weightlessness, there are many stress factors that bombard astronauts and cosmonauts inhabiting long duration vehicles. With increased stress levels, stress sensitivity increases. One of the goals of the ISS discipline is to minimize the environmental stress factors as much as possible. This experiment measured the acoustical signatures in the exercise area, workstations, and habitation modules within the Mir space station. Questionnaires were also filled out by the crew to ensure thoroughness. With this information, protective steps can be implemented and sound dampening measures incorporated into the ISS. Researchers

for this experiment were from the NASA Johnson Space Center.

Mir Wireless Network Experiments:

This experiment, designed to test a wireless network system in the Mir environment as a possible network for remote microgravity sensors to be used on the ISS, was not used, but left on board Mir for future tests. The network monitor program could measure performance and consisted of three mobile computer nodes: a wireless network server, a subnotebook computer, and a Personal Digital Assistant. Researchers for this experiment were from the NASA Ames Research Center.

Shuttle/Mir Alignment Stability

Experiment: Star tracker systems and inertial measurement units are integral to the navigation systems of both the Mir and the shuttle. This experiment entailed multiple three-hour data collection periods during the docked phase when navigational-dependent events occur (i.e. thruster firings, IMU alignments, or inertial attitude hold). These data were used to determine the stability, and sources of any instability between, the shuttle and Mir navigation systems while the two vehicles are docked. Researchers for this experiment were from the NASA Johnson Space Center and NPO Energia.

Microgravity Protein Crystal Growth

Dewar Experiment: Development of crystals in space is of interest to researchers because the crystals grown are more pure and generally more free of defects than those that crystallize in our gravitational environment on Earth.

Before the flight, frozen solutions from which the crystals grew were loaded into the dewar, launched on the shuttle, and then transferred to the Mir. Once onboard the Mir, the samples slowly thawed and the crystallization process was initiated. Researchers for this experiment were from the University of California, Riverside, CA, Russia's NPO Energia and Microgravity Space Acceleration.

Space Acceleration Measurement

System Experiment: Materials science experiments require a very stable environment to yield the best results. Thruster firings and movements of the crewmembers cause random vibrations and accelerations which can affect an

experiment, possibly compromising the results. The Space Acceleration Measurement System (SAMS) records these fluctuations in the microgravity environment so that researchers can apply this information when interpreting the results of an investigation. By characterizing the acceleration environment of the space vehicle, researchers can learn where regions of high acceleration forces exist, avoiding those areas for experiment placement. Researchers for this experiment were from the NASA Lewis Research Center and the Russian Institute of Biomedical Problems

IMAX CARGO BAY CAMERA (ICBC): The crew used an IMAX Cargo Bay Camera to document *Atlantis'* rendezvous and docking with the Mir station. After the mission, selected still images from the film were made available to the public via the Internet. NASA is using the IMAX film medium to document its space activities and better illustrate them for the public. This system, developed by IMAX Systems, Corp., Toronto, Canada, uses specially designed motion picture cameras and projectors to record and display high definition, large-screen pictures. ICBC was managed by the NASA Johnson Space Center.

Shuttle Glo Experiment (GLO-4): Scientists continue to investigate the mysterious shroud of luminosity, called the "glow phenomenon," observed by astronauts on past shuttle missions. The effects of ambient magnetic field, orbit altitude, mission elapsed time, shuttle thruster firings, and surface composition on the intensity and spectrum of the glow also were measured. An optical emission model was then developed from the data. Phillips Laboratory and the University of Arizona are co-principal investigators on GLO.

Photogrammetric Appendage Structural Dynamics Experiment (PASDE): This experiment photogrammetrically recorded structural response data of the Mir solar arrays during the docked phase of the mission. These data were analyzed on the ground to verify the use of these techniques to characterize the structural dynamics of the array demonstrating that this technology can result in cost and risk reduction for

the ISS. The payload was managed by Goddard Space Flight Center's Special Payloads Division.

SHUTTLE AMATEUR RADIO EXPERIMENT-II (SAREX-II):

Students in the U.S. had a chance to speak via amateur radio with astronauts aboard the Space Shuttle *Atlantis* during STS-74. Ground-based amateur radio operators ("hams") were able to contact the shuttle astronauts through a direct voice ham radio link.

Crew biographies

Commander: Kenneth Cameron (Col., USMC). Cameron, 45, was born in Cleveland, OH, and received a bachelor of science and masters degrees in aeronautics and astronautics from MIT.

He enlisted in the Marine Corps, ultimately becoming an infantry platoon commander in Vietnam. Cameron served in a variety of roles as a test pilot, project officer and aviation instructor, earning special honors which include the Defense Superior Service Medal, the Distinguished Flying Cross and the Marine Corps Association Leadership Sword. Most recently, Cameron served as the first NASA Director of Operations at the Gagarin Cosmonaut Training Center in Star City, Russia, where he worked with Russian training personnel and officials in setting up a support system for astronaut training and operations for the Phase 1 program.

Cameron served as the Pilot on the STS-37 mission in 1991, which featured the deployment of the Compton Gamma Ray Observatory and a pair of space walks, one of which advanced techniques for ISS construction. Cameron then commanded the ATLAS-2 mission in 1993 which studied atmospheric and solar activity. With the completion of STS-74 he has logged more than 561 hours in space.

Pilot: James Halsell (Lt. Col., USAF). Halsell, 39, was born in West

Monroe, LA, graduated from the U.S. Air Force Academy with honors in engineering and aeronautics and was assigned to Nellis Air Force Base, NV, where he served as an aircraft commander. After tours of duty as a test pilot and fighter pilot, Halsell became a test pilot at Edwards Air Force Base, CA.

Halsell has served as part of the Astronaut Support Personnel team at the Kennedy Space Center which prepares space shuttle vehicles for flight, and worked as a spacecraft communicator (CAPCOM) in Mission Control for several flights.

Halsell was the Pilot on the STS-65 mission in 1994 in which seven astronauts spent 15 days conducting more than 80 microgravity research experiments in a Spacelab module in *Columbia's* cargo bay. With the completion of this mission he logged more than 545 hours in space.

Mission Specialist: Chris Hadfield (Major, Canadian Air Force). Hadfield, 36, was born in Sarnia, Ontario, Canada. He graduated from the Royal Military College in Kingston, Ontario, Canada with a bachelor's degree in mechanical engineering with honors and earned a master's degree in aviation systems from the University of Tennessee after conducting post-graduate research at the University of Waterloo in Ontario, Canada.



In-flight crew portrait taken in front of docking module: Upside down with his head near bottom center are Commander Ken Cameron. Clockwise from there are Pilot James Halsell and Mission Specialists Chris Hadfield, William McArthur and Jerry Ross.

STS-74 Quick Look

Launch Date: November 12, 1995

Site: KSC Pad 39A

Time: 6:31 a.m. CST

Orbiter: *Atlantis*
(OV-104)
15th flight

Orbit/Inc.: 160 nautical miles
51.6 degrees

Mir Docking: November 15, 1995
12:28 a.m. CST

Mir Undocking: November 18, 1995
2:16 a.m. CST

Mission Duration: 8 days,
4 hours,
3 minutes

Landing Date: November 20,
1995

Time: 11:02 a.m. CST

Site: Kennedy Space Ctr.

Crew: Ken Cameron, CDR
Jim Halsell, PLT
Chris Hadfield, MS1
Jerry Ross, MS2
Bill McArthur, MS3

Cargo: Docking Module
Bay: Orbiter Docking
System

Payloads: IMAX
GLO

In-Cabin Payloads: SAREX

School's Flight Test Engineer Course and was assigned to duties at Edwards Air Force Base, CA. Ross's technical assignments with NASA have included work with extravehicular activity issues and the remote manipulator system, working as a spacecraft communicator (CAPCOM) in Mission Control and as chief of the Mission Support Branch.

Ross first flew in 1985 on STS-61B in which three communications satellites were deployed. He conducted two space walks to test ISS construction techniques. Ross' second flight was STS-27 in 1988, a dedicated mission for the Department of Defense. Ross flew again on STS-37 in 1991, in which the Compton Gamma Ray Observatory was deployed. On that flight, he performed two more space walks to help free a stuck antenna on the GRO and to test ISS assembly hardware. Ross' last flight took place in 1993 on STS-55, in which he served as payload commander for the German-sponsored D-2 Spacelab mission. With STS-74 he had logged more than 845 hours of space flight.

Mission Specialist: William McArthur (Lt. Col., USAF).

McArthur, 44, was born in Laurinburg, NC, but considers Wakulla, NC, to be his hometown. He graduated from West Point with a bachelor of science degree in applied science and engineering and a master's degree in aerospace engineering from Georgia Tech.

McArthur was the top graduate of his flight class at Army Aviation School and was designated an Army aviator. He then graduated from the U.S. Naval Test Pilot School and was designated an experimental test pilot. McArthur is a master Army aviator. He was assigned to the Johnson Space Center as a shuttle vehicle integration test engineer, and served as a member of the Emergency Escape and Rescue Working Group before becoming an astronaut.

McArthur has served in a number of capacities, including work as a technical adviser to the solid rocket booster and redesigned solid rocket motor projects and as a spacecraft communicator (CAPCOM) in Mission Control. McArthur's first flight came in 1993 as a mission specialist on STS-58, a dedicated Space Life Sciences



The STS-74 crew patch depicts the Orbiter *Atlantis* docked to the Russian Space Station *Mir*. The central focus is on the Russian-built docking module, shaded to accentuate its pivotal importance to both STS-74 and the NASA-Mir Program. The rainbow across the horizon represents the Earth's atmosphere, the thin membrane protecting all nations, while the three flags across the bottom show those nations participating in STS-74: Russia, Canada, and the United States. The sunrise is symbolic of the dawn of a new era in NASA space flight, that of space station construction.

mission in which dozens of experiments were conducted to test the human body's adaptability to the microgravity environment. Following STS-74 he had logged more than 528 hours of space flight.

Hadfield joined the Canadian Armed Forces, flying CF-18 "intercept" fighters for the North American Aerospace Command (NORAD). He attended test pilot school at Edwards Air Force Base, CA, and served as an exchange officer with the U.S. Navy at Patuxent River Naval Air Station, MD. His NASA assignments with included technical and safety issues, shuttle glass cockpit development and launch support at the Kennedy Space Center. Including STS-74 Hadfield has more than 192 hours of space flight.

Mission Specialist: Jerry Ross (Col., USAF). Ross, 47, was born in Crown Point, IN, and graduated from Purdue University with bachelor's and master's degrees in mechanical engineering before entering active duty with the Air Force. Ross graduated from the USAF Test Pilot